Long-Lived Particles Working Group: The theoretical perspective

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1st LLP Working Group Meeting, CERN, 27.05.2020

What do pheno-LLP'ers want?

Their favourite model

Is it visible in existing searches? YES → Reinterpretation →

↓ NO

Can new searches be designed for this?

1. Why is it missed? (no efficient triggers? Thrown away as pileup/UE junk? No dedicated search for its leading signature?)

   ↪ Collaborate with experimentalists
   ↪ Can we see the trigger menu?

2. If missed because of non-optimal cuts or a completely new signature: can a theorist simulate or calculate the BG?

   ↪ Collaborate with experimentalists
   ↪ Push to publish backgrounds that can not be simulated

What can pheno-LLP'ers do?

1. Provide standardised simplified models targeting specific *signatures*
↪ Some work layed-out in the LLP@LHC White Paper.

2. Provide standardised tools, e.g: UFO models, MC for dark showers.

3. "Focus group" for reinterpretation material:
↪ Published material suffices to reproduce the published benchmarks?
↪ Detailed recommendations & wishes formulated in 2003.07868.

4. Suggest analysis and presentation improvements
↪ Standardize object definition, e.g: "Displaced Jets" or "Disappearing tracks" can be Delphes object with displacement information inside.

5. Keep an updated survey of coverage gaps:
↪ Preliminary work done for the LLP@LHC White Paper

6. … < your input here! >

Reinterpretation

The devil is in object definition details

1. Can it be easily translated into a “universal” language?

   (This has been done e.g. for jet definitions: they are same for generator particles and calorimeter deposits)

   Ideas:
   ↪ Give efficiencies on objects made out of charged tracks/ calo deposits (both can be reasonably done with Delphes)
   ↪ Give efficiency maps based on detector geometry (e.g. DV efficiencies in different R slices)

2. Can the efficiencies be provided in a relatively model independent way?

   Ideas:
   ↪ Use multiple benchmarks with different topologies
   ↪ Provide closure tests (how well do the efficiencies reproduce the limits?)
   ↪ Make full sim available (as a pre-compiled binary on a virtual machine that takes in HepMC? For a few signal models?) so we can test ourselves.

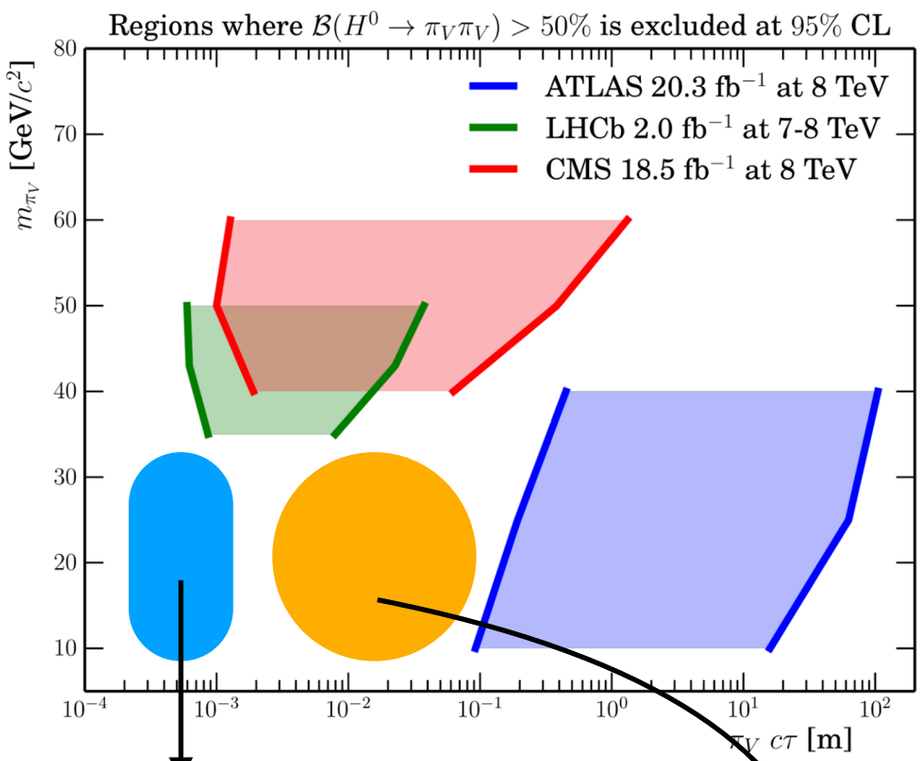
Machine Learning

- Becoming popular even with the theory community
- Main problem is availability of background events to train
  - ↪ Can we use Open Data?
  - ↪ Can we have “simplified” background events?
  - ↪ Background from non-MC sources?
- How close does generator data come to reality?
  - ↪ Publish full-sim for a few agreed-upon benchmarks (e.g. H →SS→4j, Z’→μμ, L’→$\ell\nu$)

An illustrative example: Exotic Higgs decays

LLP searches rely on existing triggers which may miss certain signals (see last session!)

Higgs as source of BSM: H(125) → LLP LLP → 4b for m_{LLP} ~ [10-35] GeV



B-mesons: huge bgd, computationally very expensive

BR(H →bb) ~ 90%, BG is non-B mesons
How well can we reject light, displaced jets?

13 TeV data would cover more terrain, but the message that light masses and low lifetimes are challenging remains.
These gaps motivate new strategies, and also influence the case for future colliders.

- Comparing ATLAS, CMS & LHCb 7-8 TeV data (haven't found a version with 13 TeV studies!) And FASER (and others…) can be added here at no cost.
- Luckily, here all experiments chose the same model. But e.g: LJ searches use different dark photon models. <u>Same type of studies should share a common benchmark</u>. (ideally many, with different kinematical features!)
- Warning: Benchmarking can lead to misleading conclusions! A signature-based approach is desirable… but can we motivate a search without a theory model supporting it?
- We could do this plot for the current 95% C.L H->inv bounds. If H->inv shows an excess, we would have a possible interpretation! (connection with the newly named "LHC Higgs WG".)
- The model is simple enough as to be recasted to others. Studies also use RPV SUSY (squarks, gluinos), which have DV -> jjl or jjj decays, not just DV-> jj. (Have a similar RPV SUSY plot?)
- Would this plot change with LLP spin? with LLP decay mode?
- Should we produce / endorse such summary plots?